Applications of Water Vapor-derived Multispectral Composites for Geostationary Satellites

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Keywords: RGB composite imagery, vertical distribution of moisture

Motivation

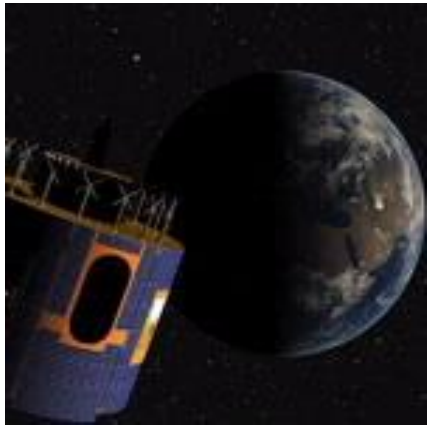
Rich data sources of geostationary multispectral imagery to look at unique spatial and temporal variations in water vapor which can play an important role in the development of high impact weather events


GOES_R

Multispectral image data provides Red-Green-Blue (RGB) composite products which qualitatively portray different aspects of atmospheric moisture variation


Himawari

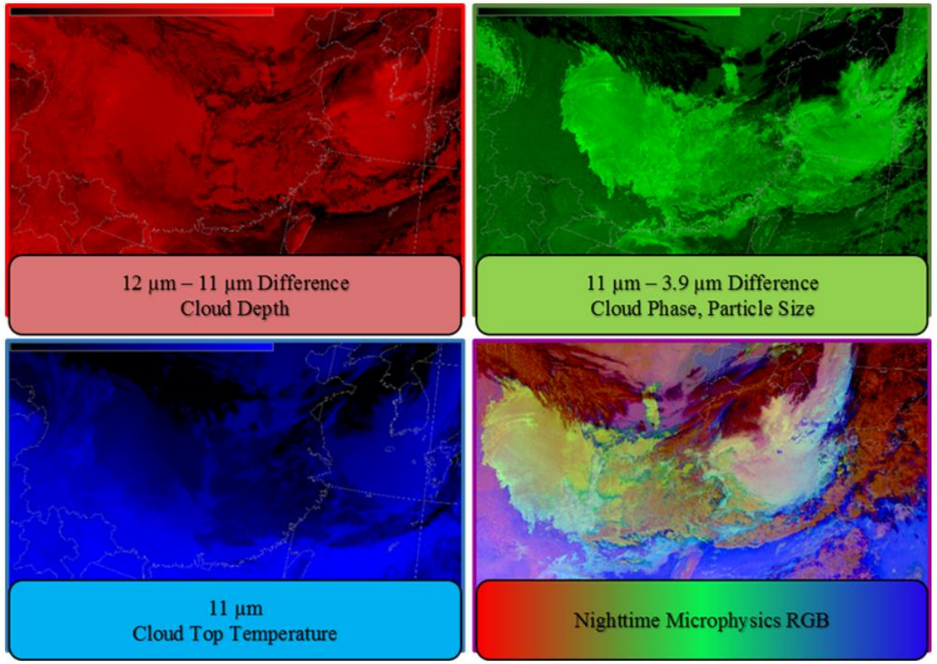
Need to better understand the complementary nature of these products to diagnose important aspects of weather systems


MSG

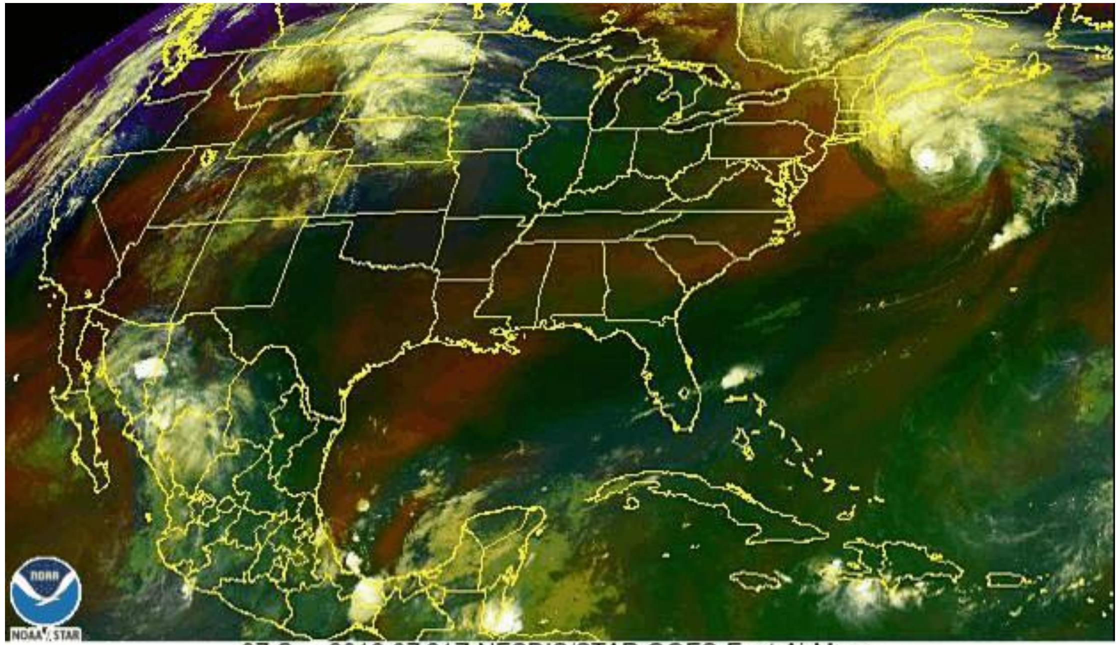
Utility of RGB Composites

Combining individual channels or channel differences enhances the utility of the individual channel imagery and simplifies qualitative interpretation of weather features.

Animation of RGB products from geostationary satellites enhances the understanding of the changing dynamic environment.



Night-time Microphysics RGB



07 Sep 2019 07:21Z NESDIS/STAR GOES-East AirMass

AM and DWV RGB Composite Products

Marshall Space Flight Center

Earth Science Branch

Air Mass RGB

Developed by EUMETSAT to evaluate temperature and moisture characteristics of developing synoptic weather systems

RGB Derivation

Color	Band / Band Diff. (µm)	Min – Max Gamma	Physically Relates to…	*Small input to pixel indicates…	*Large input to pixel indicates…
Red	6.2 – 7.3	-26.2 to 0.6 C 1	Vertical water vapor difference	Moist upper levels	Dry upper levels
Green	9.6 – 10.3	-43.2 to 6.7 C 1	Tropopause height based on ozone	Low trop and high ozone	High trop and low ozone
Blue	6.2 (inverted)	-29.25 to -64.65 C 1	Water vapor ~200-500 mb	Dry upper levels	Moist upper levels

Interpretation

- Jet stream; potential vorticity; dry upper levels
- Cold Air Mass
- Warm Air Mass
- Warm Air Mass, less moisture
- Limb Effects
- Warm low-level clouds
- Cold low-level clouds
- Mid-level clouds
- High, thick clouds

Composites allow for a quick qualitative assessment of the structure of synoptic weather systems but atmospheric absorption away from satellite sub point creates misleading color variations in the imagery.

Differential Water Vapor RGB

Developed by JMA to understand variations in mid-upper level water vapor, horizontal moisture boundaries, trough / ridge patterns

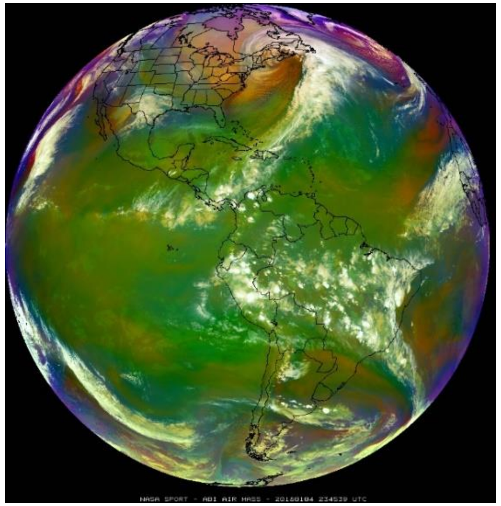
RGB Derivation

Color	Band / Band Diff. (µm)	Min – Max Gamma	Physically Relates to…	*Small contribution to pixel indicates…	*Large Contribution to pixel indicates…
Red	7.3 – 6.2 (inv)	30 to -3 C 0.2587	Vertical water vapor difference	Moist upper levels	Dry upper levels
Green	7.3 (inv)	5 to -60 C 0.4	Low level water vapor	Dry low levels	Moist lower levels
Blue	6.2 (inv)	-29.25 to -64.65 C 0.4	Upper level water vapor	Dry upper levels	Moist upper levels

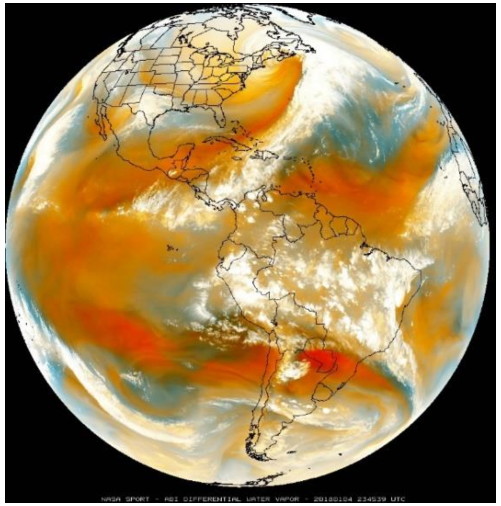
Interpretation

- Very dry mid-upper level
- Dry mid-upper level
- Dry mid-upper level; Moist mid level; Mid level cloud
- Moderate moisture mid-upper level
- Moist upper level
- High, thick clouds

2345 UTC 04 Jan 2018



Air Mass RGB



DWV RGB

Correction for Limb Absorption Effects

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Limb correction for increased atmospheric water vapor and ozone away from satellite sub-point allows for more accurate imagery for interpretation (Elmer et al., 2019)

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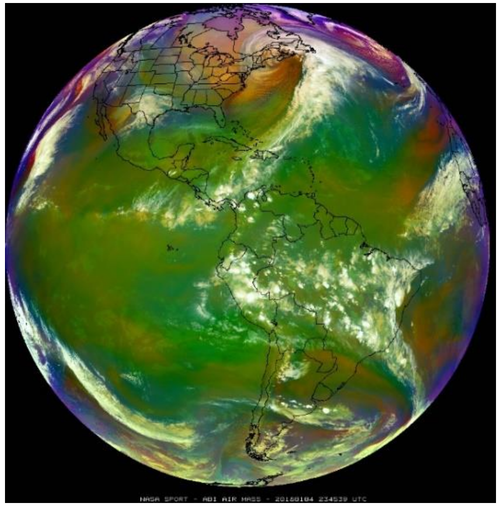
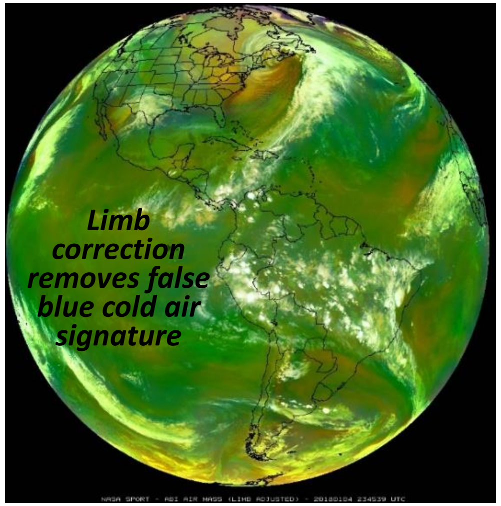
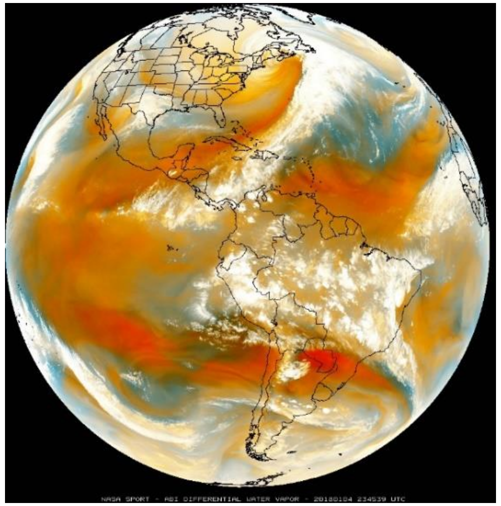


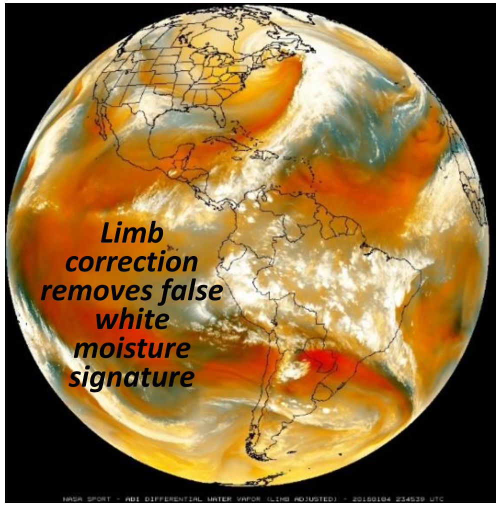
Air Mass RGB



Limb Corrected Air Mass RGB



DWV RGB



Limb Corrected DWV RGB

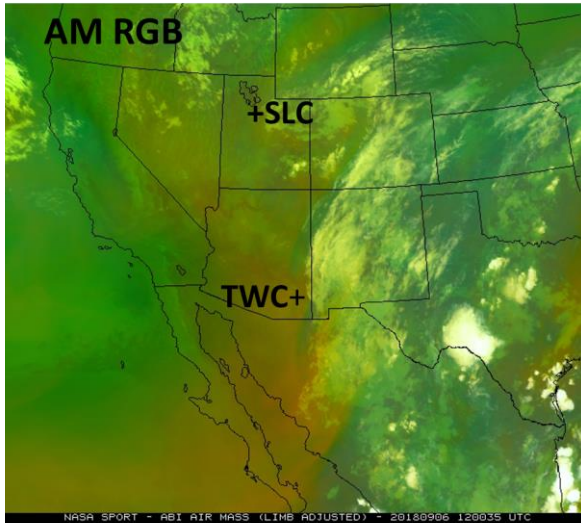
See Elmer et al. (2019)

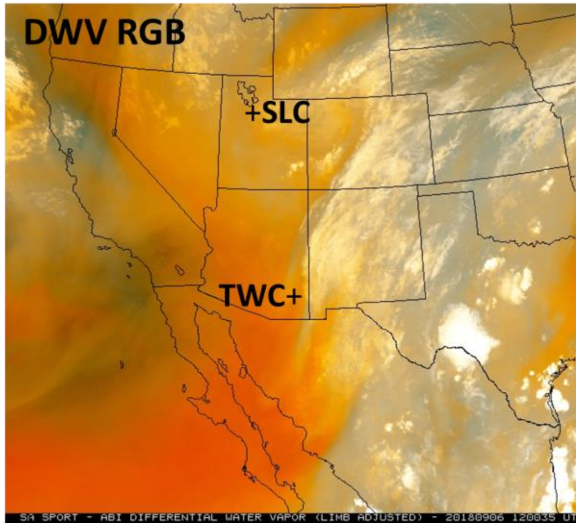
Application of AM and DWV Composites

Marshall Space Flight Center

Earth Science Branch

1200UTC 06 September 2018





AM RGB

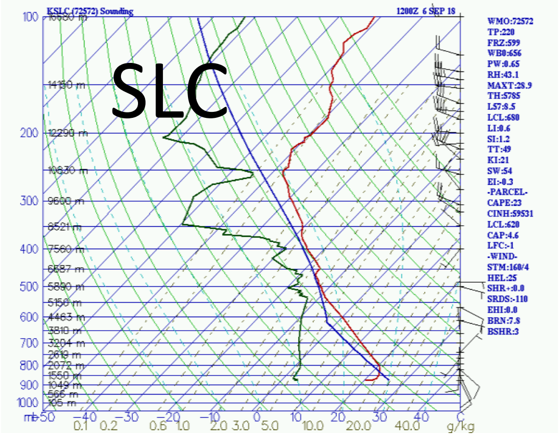
Tucson, AZ (TWC): Warm, tropical air mass offshore and inland. More orange tones indicate a decrease in upper-level moisture within the same air mass.

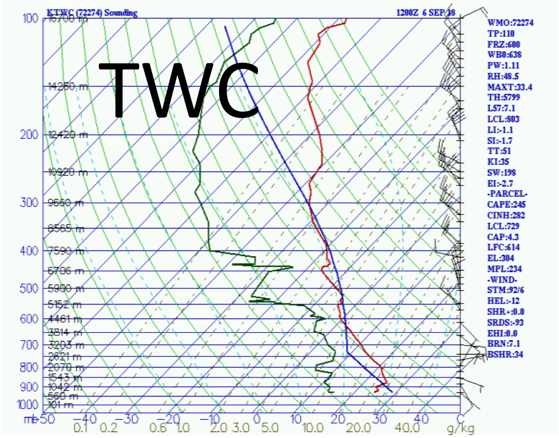
Salt Lake City, UT (SLC): Low to mid level clouds and green tones indicate more low to mid level moisture

DWV RGB

Tucson, AZ (TWC): Orange and blue colors offshore indicating upper level moisture over a thick dry layer. Increasing deep layer dryness inland

Salt Lake City, UT (SLC): lighter orange, blue, and gray tones indicate increasing mid to upper level moisture





TWC sounding confirms the deep layer dryness indicated by the DWV RGB and decrease in moisture in the AM RGB

SLC sounding confirms increasing mid- and upper level moisture

Application of AM and DWV Composites

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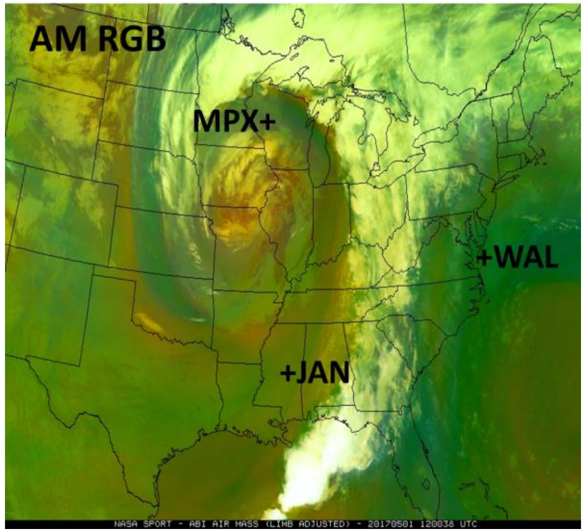
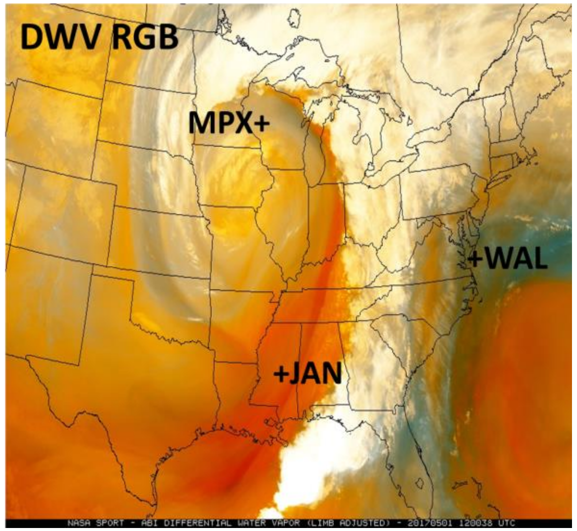
1200UTC 01 May 2018





AM RGB

Jackson, MS (JAN): warm, dry air in olive and orange tones representative of the dry slot

Chanhassen, MN (MPX): increase in upper level moisture in green tones where the dry slot is not influencing the region

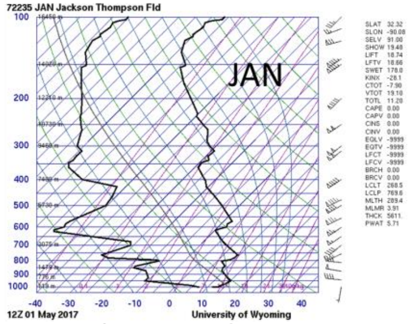
Wallops Is, VA (WAL): warm, moist air offshore ahead of the advancing cold front

DWV RGB

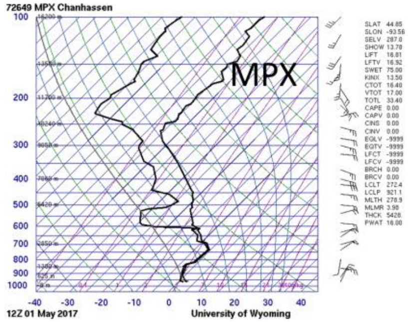
Jackson, MS (JAN): Deep orange tones indicate deep layer dry air verified by JAN sounding

Chanhassen, MN (MPX): increased low to mid level moisture evidenced by the gray color and in MPX sounding

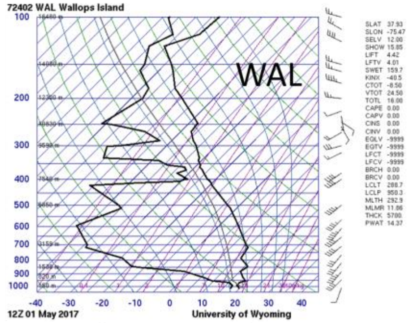
Wallops Is, VA (WAL): bluish-green color indicates moist upper levels with dry air below also seen in WAL sounding



Jackson, MS sounding
1200 UTC 01 May 2018



Chanhassen, MN *sounding*
1200 UTC 01 May 2018



Wallops, Is., VA sounding
1200 UTC 01 May 2018

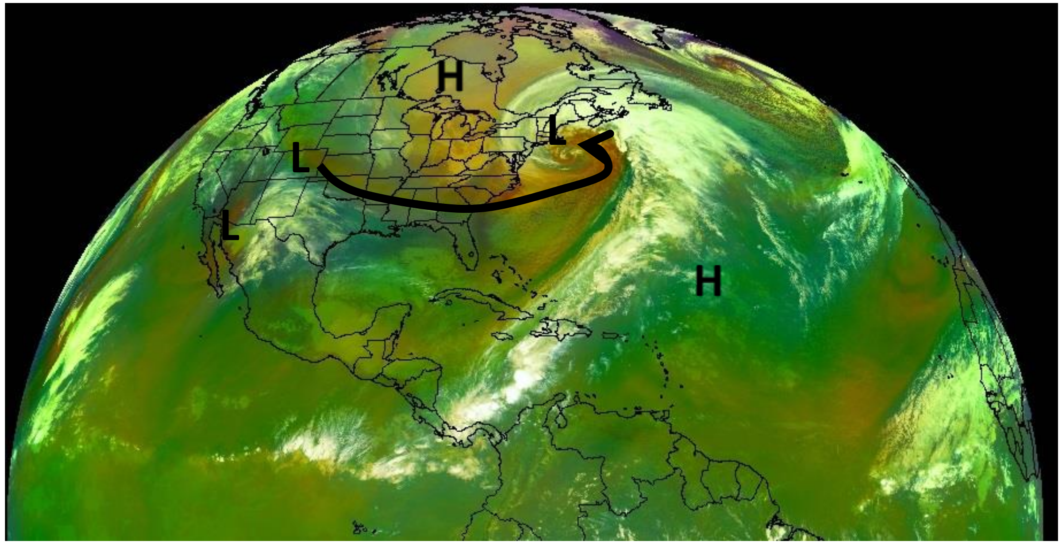
Application of AM and DWV Composites

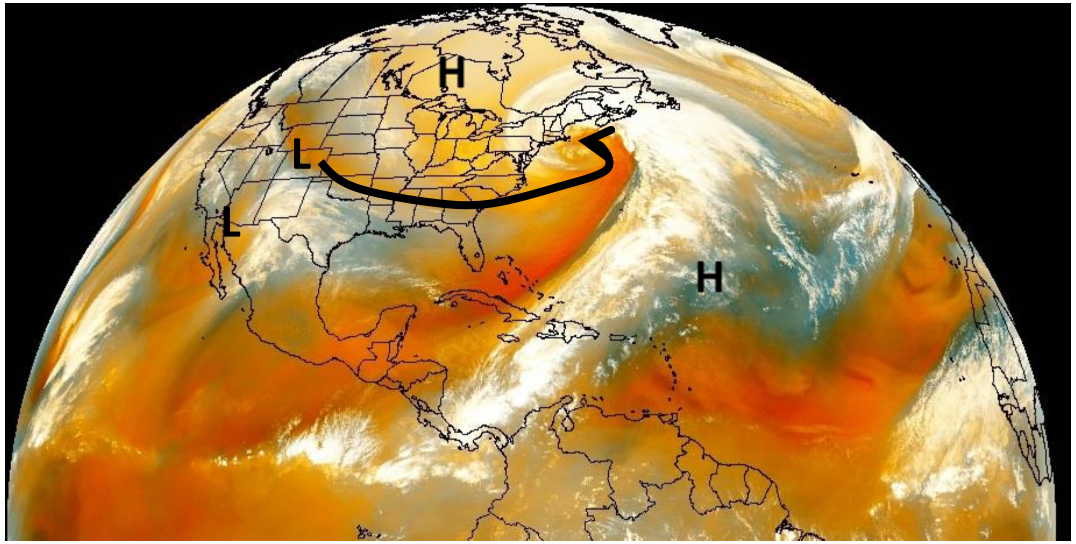
AM RGB

- Strong high pressure over Atlantic and central Canada with very strong low over New England, weak low over Baja.
- Red-orange colors indicate decreasing upper level moisture, jet stream, and PV anomaly from Midwest into the Low.

DWV RGB

- Contrasting colors in DWV RGB composite allows for easier interpretation of vertical moisture variability
  - Blue colors associated with Atlantic High indicates dry layer beneath the upper level moisture
  - Lighter orange in western Plains indicative o increased low mid-level moisture
  - Grey colors in advance of clouds in Southwest indicate both mid- upper-level moisture





Summary and Conclusions

AM and DWV RGB composite imagery highlights 3-D differences in the temperature and moisture structure associated with synoptic weather systems that may otherwise go unnoticed because of the complexity of manually evaluating many individual channels of data.

Important to have guidance on the interpretation of the qualitative RGB imagery. Case study examples and interpretation guidance is useful to gain greater understanding of the utility of these RGB products.

Use of limb-corrected imagery is necessary for interpretation of RGB features located >40% from satellite sub-point.

RGB imagery comparison

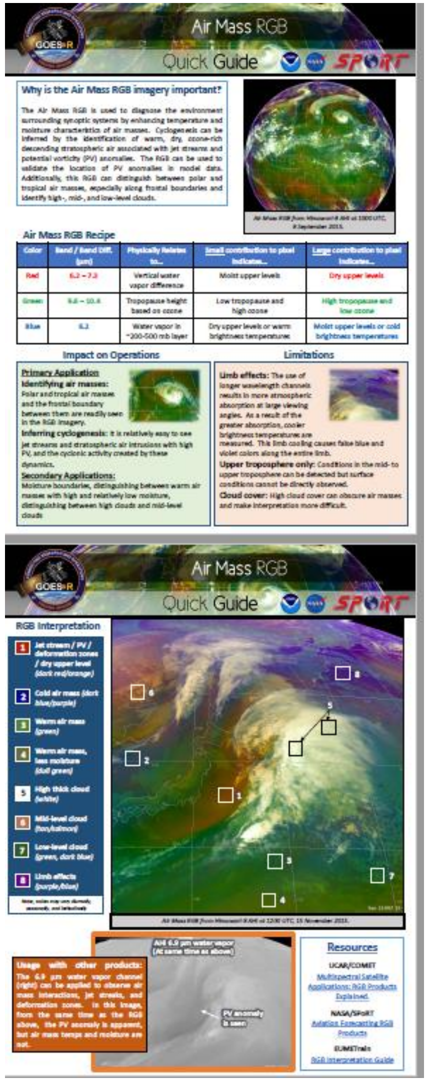
- AM RGB composite highlights variations in tropopause height and upper-level water vapor variability
- DWV RGB highlights additional vertical variability in mid- and upper-tropospheric water vapor structure which may not be apparent in the AM RGB imagery.

Additional Information / References

NASA Short-term Prediction Research Transition (https://weather.msfc.nasa.gov/sport)

Real-time GOES-16 / 17 data (https://weather.msfc.nasa.gov/goes)

Quick Guides for RGBs (https://nasasporttraining.wordpress.com/quick-guides)



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